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Seed Dormancy Status of Tropical Weedy Rice Population in Malaysia
(Status Dorman Benih bagi Populasi Padi Angin Tropika di Malaysia)

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ABSTRACT

Seed dormancy is a trait that promotes the survival of weedy rice (*Oryza sativa* L.) in the rice seed bank. Weedy rice displays different level of dormancy depending on several factors including genetic control. Determining seed dormancy status of weedy rice is crucial to understand adaptive mechanism of the weed in the rice agroecosystem especially in the tropic regions. To investigate the degree of seed dormancy of weedy rice, 66 weedy rice seed samples were collected from Selangor rice fields. The degree of seed dormancy was determined by standard germination test at 7, 14, 21, 42, 49, 56, 63, and 284 days after imbibition. The dormancy status of weedy rice after >200d in room temperature storage was compared. A total of 92.4% of weedy rice samples displayed a high degree of dormancy upon maturation. The germination rates of sampled weedy rice are divergent, indicating weedy rice in the tropical regions has variation in the degree of seed dormancy. The cumulative germination rate was gradually increased over time and reached total dormancy loss at 284 days after the initial imbibition. The germination rate of weedy rice after >280 days in dry storage displayed a bimodal distribution pattern, with 25.8% and 18.2% of sampled weedy rice showed a strong and weak seed dormancy, respectively. This study showed that weedy rice seeds in Malaysia displayed a high degree of seed dormancy and can retain their viability more than 200d once imbibed. This trait can enhance the survivability of weedy rice in the tropical rice agroecosystems.

Keywords: Seed bank; seed dormancy; seed longevity; tropical region; weedy rice

ABSTRAK

Kedormanan biji benih adalah sifat yang mendorong kelangsungan hidup padi angin (*Oryza sativa* L.) di dalam bank benih padi. Padi angin menunjukkan tahap kedormanan yang berbeza bergantung kepada beberapa faktor termasuk kawalan genetik. Penentuan status kedormanan benih padi angin adalah sangat penting untuk memahami mekanisme adaptasi padi angin di dalam agroekosistem padi terutama di kawasan tropika. Sebanyak 66 sampel benih padi angin telah dikumpulkan daripada sawah padi di Selangor bagi mengkaji tahap kedormanan benih padi angin. Tahap dormansi benih ditentukan oleh ujian percambahan piawai pada 7, 14, 21, 42, 49, 56, 63, dan 284 hari selepas pemedapan. Status kedormanan padi angin setelah > 200 hari berada pada penyimpanan suhu bilik dibandingkan. Sebanyak 92.4% sampel padi angin menunjukkan tahap kedormanan yang tinggi semasa padi matang. Kadar percambahan padi angin yang disampel adalah berbeza menunjukkan padi angin di kawasan tropika mempunyai variasi dalam tahap kedormanan biji benih. Kadar percambahan kumulatif secara beransur-ansur meningkat dari masa ke masa dan mencapai kehilangan kedormanan keseluruhan pada 284 hari setelah pemedapan awal. Kadar percambahan padi angin setelah > 280 hari di tempat penyimpanan kering menunjukkan corak taburan bimodal dengan 25.8% dan 18.2% padi angin yang disampel masing-masing menunjukkan dormansi biji yang kuat dan lemah. Kajian ini mendapati bahawa biji padi angin di Malaysia menunjukkan tahap kedormanan benih yang tinggi dan dapat mengekalkan daya hidupnya lebih dari 200 hari setelah dipedap. Sifat ini dapat meningkatkan kelangsungan hidup padi angin di dalam agroekosistem padi tropika.

Kata kunci: Bank benih; kawasan tropika; kedormanan benih; kelanjutan usia benih; padi angin

Introduction

Naturally, weed plants tend to have seed dormancy trait that plays a critical role in adaptation and survival, especially in agricultural ecosystems (Gu et al. 2006; Walters et al. 2005). Weed seeds, usually dormant upon maturation, may survive in the soil for months to years, depending on its genotypes and environments (Hang et al. 2015; Sasaki et al. 2015). This trait delays the germination of the viable seeds even under favourable conditions (Baskin & Baskin 2014; Gu et al. 2005). The variability in germination timing will ensure its progeny survival by continuous germination in the rice field seed bank for the next subsequent seasons (Gu et al. 2005; Mispan et al. 2013).

Seed dormancy trait in weedy rice (*Oryza sativa* L.) gives advantages for the weedy rice to survive in the rice production system. For example, seed dormancy provides persistence for weedy rice to persevere in an agricultural land through the survivability of their seeds in the soil as a seed bank (Juraimi et al. 2012; Mispan et al. 2019). Maintaining viability over periods in the seed bank through dormancy might provide several adaptive advantages for weed seeds to survive from heat and high humidity and escape seed deterioration (Kapoor et al. 2011; Noldin et al. 2006; Siddique et al. 1988; Walters et al. 2005)

Dormancy is a genetically complex trait controlled by polygenes with effects modified by the genetic background and environmental factors (Gu et al. 2006; Hang et al. 2015; Li et al. 2012; Suh et al. 1997; Tseng et al. 2013). Many ecological and extensive genetics studies have been done on seed dormancy in weedy rice, especially for temperate regions (Gu et al. 2011; Mispan et al. 2013; Ye et al. 2015). Seed dormancy in weedy rice varied depending on the local habitat temperature, where seed dormancy in the temperate regions was reportedly weaker than in the tropical countries (Xia et al. 2011). However, the current state of dormancy status of weedy rice especially from the tropical countries is unknown.

Thus, this study aimed to investigate the variation of seed dormancy in weedy rice populations in Malaysia which could contribute to better understanding of the nature of seed dormancy in weedy rice, especially in tropical regions.

Materials and Methods

Weedy Rice Seed Collection

Weedy rice sample collection was conducted at IADA, Northwest of Selangor (3°46'N, 101°20'E) during the harvesting period in January 2018. Weedy rice sample locations were randomly selected from farm blocks with a high infestation of weedy rice. Weedy rice was determined in the field based on five distinct morphological traits i.e. height, hull colour, pericarp colour, the presence of awn, and shattering capability (Supp. Table 1). Weedy rice was sampled when they have at least one of these characteristics, including high seed shattering, black or furrowed hull, presence of awn, pigmented pericarp, and tall stature (>100 cm). Seeds of each weedy rice were hand-threshed directly in the field and immediately placed in a paper bag. Seed samples were cleaned and separated from extraneous materials, air-dried in the greenhouse for three days, and equally separated into two sets of bags.

Germination Test for Seed Dormancy Assessment

The first set of weedy rice samples was tested for seed dormancy using the standard germination method described in Mispan et al. (2013). The second set of weedy rice samples were left at room temperature in dry conditions to determine the after-ripening effect on the degree of dormancy.

The standard germination test was replicated three times with 30 to 50 seeds per replication. Seeds were distributed in a 9 cm petri dish lined with a Whatman No. 1 filter paper and wetted with 10 mL distilled water. Samples were placed in an incubator set at 30 °C and 100% relative humidity in the dark. Germinated seeds were determined visually by the emergence of radical and/or coleoptiles. The number of germinated seeds was counted at every 7 days' intervals.

The non-germinated seeds were air-dried for ~4 h at room temperature after every count to prevent fungal contamination. The damaged and contaminated seeds were removed and not counted for the total. The seeds were re-soaked with distilled water in a new set of filter paper and Petri dishes to continue the germination test. Germination rate was counted at 7, 14, 21, 42, 49, 56, and 63 days. The continuous germination test was stopped at 63 days after imbibition. The remaining non-germinated seeds were cleaned and air-dried overnight. The seeds were kept in a dry, tight container at room temperature. Silica gels were put in the container to prevent moisture. The germination test was continued after 217 days of storage. The total day from the first to the second imbibition was 280d. The number of germinated seeds was counted at 14 days after imbibition.

The second set of weedy rice samples were tested for dormancy at ~280 days after room temperature storage in a dry condition. The germination test was a similar standard germination test as previously described. The germination rate was counted at 14 days after imbibition.

SEED VIABILITY TEST

The non-germinated seeds at 294 days were determined for viability using a tetrazolium (TZ) test (Peters 2000). All seeds for every replicate of the treatment were combined and 10 to 30 non-germinated seeds per weedy rice were randomly chosen for the test. Seeds were soaked again with distilled water for 24 h to retain the moisture in the seeds. The seeds were cut longitudinally through the embryo but left the distal end intact. The cut seeds were then immersed in 2 mL of 0.25% Triphenyl tetrazolium chloride (TTC) salt solution in a 3 × 3 × 1 cm plastic box for 1 h at 40 °C. The viability of the seeds was determined based on the topographical staining pattern on the embryo. A fully stained embryo (Figure 1) indicates that the seed is still viable (TZ positive). Seeds with unstained or partially stained (unstained radical and/or coleoptiles) embryo were considered dead (TZ negative). Due to limited seeds, the non-germinated seeds from the second set (room temperature treatment) were not tested with TZ test. The seeds were air-dried for 24 h and kept in a -80 °C freezer for future study.

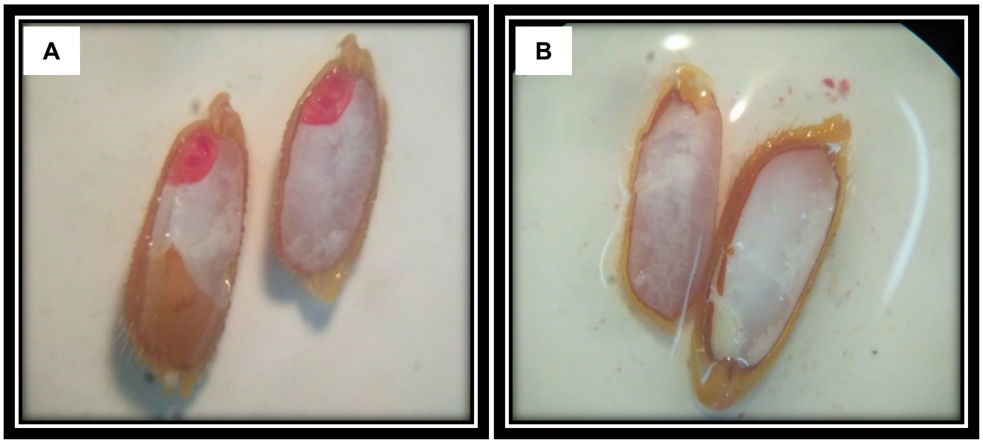

FIGURE 1. Evaluation of seed viability using tetrazolium (TZ) test. (A) TZ positive with a fully stained embryo; (B) TZ negative with unstained embryo (radical and/or coleoptiles)

DATA ANALYSIS

The difference of germination rate between time intervals were analysed using Student t-test with the level of significance at $p<0.05$. The association between traits was determined by correlation analysis using the SAS PROC CORR procedure (SAS Institute 2011).

RESULTS AND DISCUSSION

A total of 66 individuals of weedy rice were collected comprising of seeds with different morphological characteristics (Supp. Table 1). Majority of the collected weedy rice seeds possessed these characteristics; awnless (69.7%), high shattering (74.2%), red pericarp colour (71.2%), and furrowed hull (74.24%). No black-hulled weedy rice was found during the sampling.

Initial germination test at 7 days after imbibition displayed an average germination percentage of 5.98±8.30% (Figure 2(a)). A total of 92.4% of weedy rice samples were having less than 10% germination rate and the distribution skewed to low germination. A total of 17 (25.85%) samples possessed no germination during this stage. The highest germination rate was recorded by Sel-33 with 38.91% (Supp. Table 1). This indicates that the sampled weedy rice population has relatively strong primary seed dormancy during maturation.

Weedy rice acquires primary dormancy in their seeds to enhance adaptation of the weed to diverse rice agriculture environments by distributing germination over time and space to help weeds distribute and establish in the rice fields (Gu et al. 2005; Mispan et al. 2019). Strong dormancy in weedy rice samples from this study suggested the perseverance and invasiveness of the weed in the tropical rice agroecosystem. This adaptive trait is also vital for weed adaptation and determining colonization and establishment success (Mispan et al. 2013; Zimdahl 2018).

The average germination rate of sampled weedy rice significantly ($p = 0.009$) increased by 4.98% at 14 days after imbibition with an average of 10.96±12.84% (Figure 3). The germination was steadily increased by 4.72, 5.65, 1.94, 1.04, and 0.96% at 21, 42, 49, 56, and 63 days after imbibition, respectively (Figure 2(b)-2(f)). At 63 days after the first imbibition, a total of 27 (40.9%) of weedy rice still showed less than 10% germination rate (Figure 2(g)). The cumulative germination rate was relatively low, and the majority of weedy rice seeds still remain in the dormant stage. These germination distributions of all sampled weedy rice under continuous imbibition were still skewed towards a low germination rate indicating a strong degree of seed dormancy even after more than two months of imbibition. A high and significant correlation of germination percentage among intervals (Table 1) indicates a strong association of dormancy release over time.

Figure 3 shows the variation of germination rate of sampled weedy rice at each time interval. The standard errors and interquartile range (IQR) increased over time until 63 days after imbibition. The broad standard errors and wide distance between first and third quartiles indicate the divergence of the degree of dormancy among sampled weedy rice. A number of weedy rice samples (Figure 3) displayed as the outliers with a high germination rate at 7, 14, 21, 42, and 49 days suggesting these weedy rice individuals were having weak dormancy status as compared to others.

Oryza spp. in general were greatly divergent in the degree of seed dormancy and some of the most highly dormant genotypes were found among the non-domesticated accessions from wild (*O. rufipogon*) and weedy rice (*O. sativa*) (Suh et al. 1997; Vaughan 1994). These non-domesticated genotypes likely harbour major genes or alleles for seed dormancy that might have been eliminated during domestication (Mispan et al. 2013).

A total of 90.9% of the sampled weedy rice showed >70% germination rate after 294 days from the initial imbibition (Figure 2(h)). TZ test showed all the remaining non-germinated seeds were TZ negative. Therefore, we assumed that all non-germinated seeds have lost their viability. This suggested that dormancy in weedy rice in Malaysia was completely lost after 280 days once imbibed with water. This data also indicated that the majority of weedy rice can retain seed longevity at more than 70% of their seeds once the seeds were induced with water (Figure 2(h)).

On the other hand, the germination rate of weedy rice set stored at room temperature for >280d displayed a bimodal distribution pattern (Figure 2(i)). This indicates that sampled weedy rice possessed two dormancy events when kept in a dry storage condition at room temperature. A total of 57.6% of weedy rice showed a germination rate <50% and 25.8% displayed a strong degree of dormancy with <10% germination rate. Only 18.2% of weedy rice has lost >90% of dormancy after >280 days' dry storage. After-ripening is the loss of the dormant state over some period of time through the exposure of seeds to a set of environmental conditions after maturation and separation from the parent plant (Baskin & Baskin 2014). Tseng et al. (2013) reported that weedy rice in the United States (temperate region) required 90 days after-ripening time to lose the dormancy. Therefore, this study suggested that weedy rice in Malaysia (tropical region) has a longer after-ripened period than the temperate varieties. This study also demonstrated that dry conditions at room temperature can expand weedy rice dormancy and viability (Figure 2). The relationship of seed dormancy and the viability of the seeds over time has been widely discussed although there is no conclusive argument about their association. Siddique et al. (1998) reported that cultivars with low dormancy lost viability very quickly unlike the dormant cultivars which retain certain degrees of longevity. Studies on weedy rice also showed that higher dormant seeds generally have a higher rate of viable seeds after series of burial and/or storage time (Noldin et al. 2006). The role of maternal tissues, hull and pericarp to seed dormancy and longevity has been discussed (Gu et al. 2006; Pipatpongpinyo et al. 2020; Shigemune et al. 2008) which assumed that increasing of the seed age may have some association with embryonic and/endospermic factors.

Preserving seed viability in the seed storage, soil or seed bank is an additional character that allows population persistence over cropping seasons for the weedy rice (Pipatpongpinyo et al. 2020; Vaughan 1994). Understanding this regulation in the weedy rice system also can help weed scientists to apply better strategies to induce seed deterioration in weedy rice in the rice agroecosystem.

The difference in germination rate between the two sets of weedy rice from the same plant indicates the dormancy loss over time in weedy rice is triggered by continuous water imbibition. The spread of germination over a period after water imbibition increases the probability of some seeds in the weedy rice population germinate when conditions are favourable to ensure seeds survivability.

Correlation analysis shows that the dormancy trait in the sampled weedy rice has a high association (r>0.249; p<0.05) with pericarp colour (Table 1). This indicates that these traits were linked together in the Malaysian rice population. The negative correlation between pericarp colour and germination rates indicates weedy rice with red pericarp colour has strong seed dormancy. Association of dormancy and pericarp colour in the Malaysian weedy rice might come from the same functional nucleotide polymorphism in the *Rc* region on chromosome 7 as previously reported (Gu et al. 2011; Mispan et al. 2013).

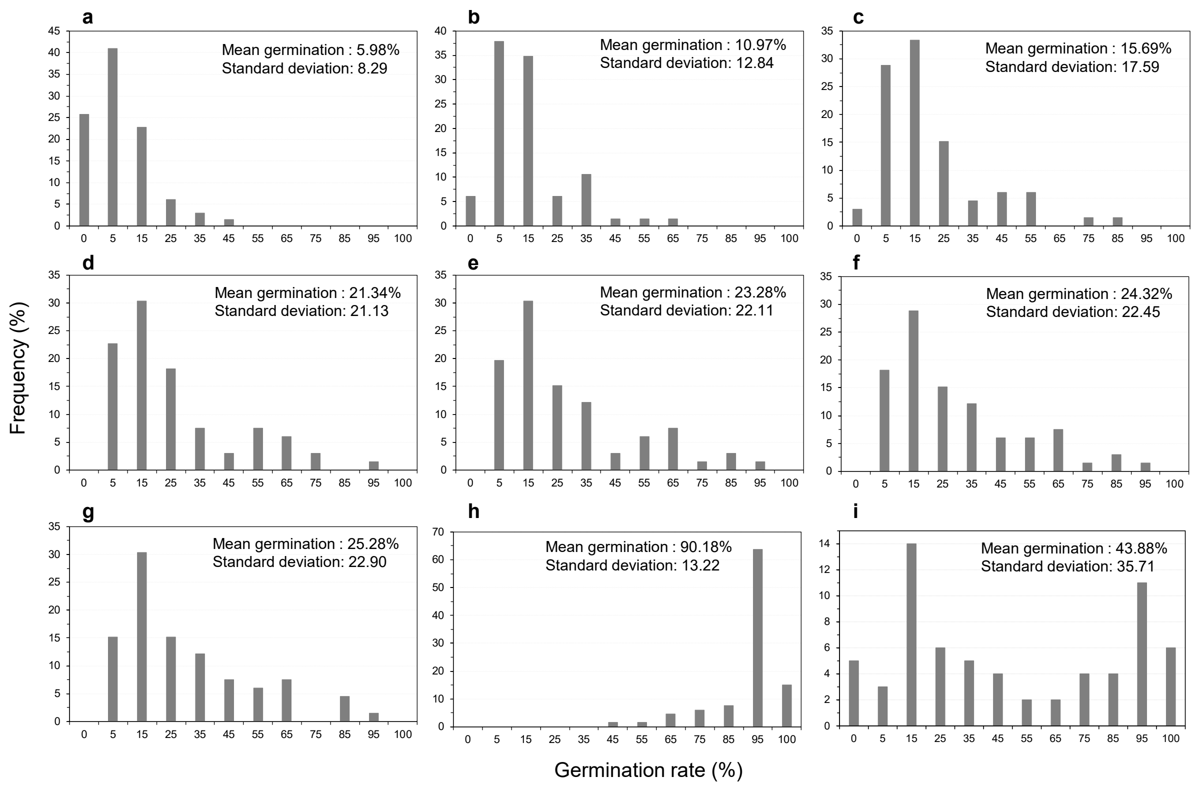

FIGURE 2. Frequency distribution of germination rate (%) of weedy rice collected from Selangor, Malaysia at different days after imbibition. a) 7d, b) 14d, c) 21d, d) 42d, e) 49d, f) 56d, g) 63d, h) 284d, and i) imbibition after 284d in dry storage at room temperature. Mean germination percentage and standard deviation of the samples are stated for each condition

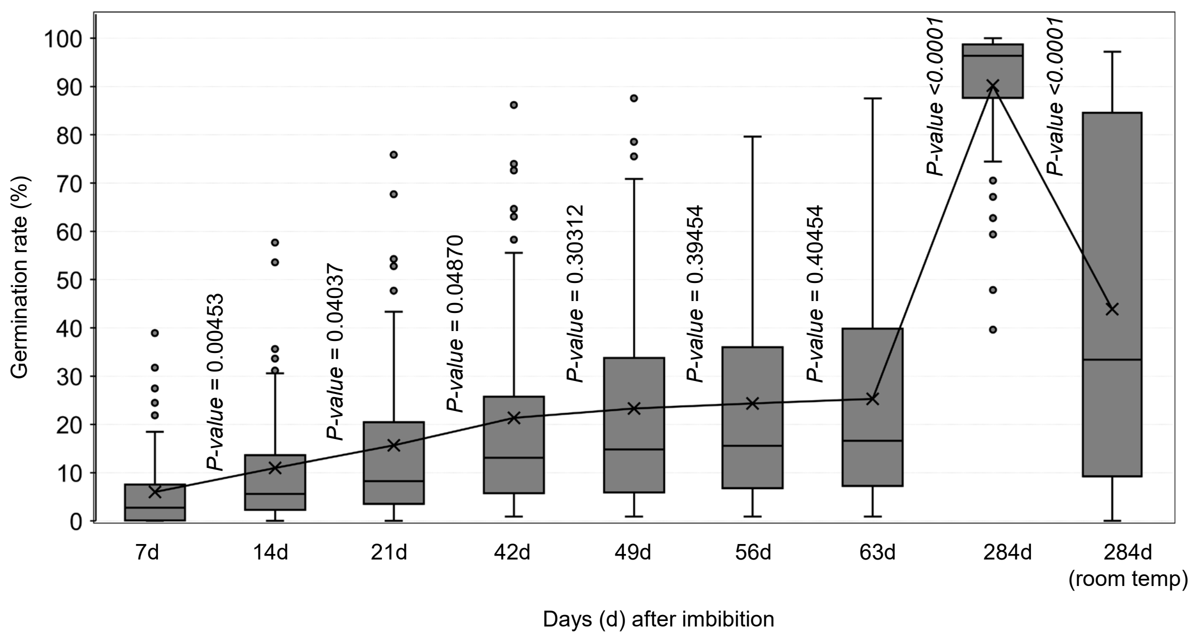

FIGURE 3. Box plot of pooled germination percentage at different days (d) after imbibition for weedy rice samples collected from Selangor, Malaysia. The grey box plot indicates the lower (Q1) and upper (Q3) quartile, representing observations outside the 25-75% percentile range. P-values in between box plot indicate the comparison significance value of the means of germination rates (x) between interval days

TABLE 1. Summary of correlation coefficients (*r*) between selected adaptive traits and germination rate at different time intervals. Values significant at *P<0.05* (N=66) are shown in bold

Traits [a]		*SD*									*PC*	*HC*	*SH*
		14 d	*21 d*	*42 d*	*49 d*	*56 d*	*63 d*	*284 d*	*284 d (RT)*				
SD	7 d	1.000											
	14 d	**0.875**	1.000										
	21 d	**0.819**	**0.990**	1.000									
	42 d	**0.737**	**0.925**	**0.951**	1.000								
	49 d	**0.713**	**0.901**	**0.931**	**0.993**	1.000							
	56 d	**0.698**	**0.884**	**0.917**	**0.985**	**0.998**	1.000						
	63 d	**0.677**	**0.866**	**0.901**	**0.976**	**0.993**	**0.997**	1.000					
	284 d	0.029	0.097	0.091	-0.001	-0.050	-0.093	-0.116	1.000				
	284 d (RT)	**-0.217**	**-0.314**	**-0.338**	**-0.432**	**-0.475**	**-0.498**	**-0.514**	**0.392**	1.000			
PC		**-0.328**	**-0.329**	**-0.321**	**-0.399**	**-0.416**	**-0.416**	**-0.403**	0.162	**0.300**	1.000		
HC		-0.046	-0.059	-0.032	-0.036	-0.019	-0.006	0.002	-0.012	-0.194	0.298	1.000	
SH		-0.163	-0.012	0.024	0.080	0.100	0.111	0.127	-0.064	-0.159	0.161	0.109	1.000
AN		-0.179	-0.196	-0.207	-0.138	-0.146	-0.149	-0.155	-0.020	0.077	-0.090	-0.313	-0.139

[a] SD, germination rate at 7d, 14d, 21d, 42d, 56d, 63d, 284d, and 284d at room temperature (RT); PC, pericarp colour; HC, hull colour; SH, seed shattering; AN, awn existence

CONCLUSION

In summary, weedy rice in Malaysia possessed a strong degree of seed dormancy and the dormancy was continuously released over time. This study also showed that weedy rice in tropic has a longer after-ripened period than the temperate regions. The dormancy release in weedy rice was influenced by the water imbibition, while the dry condition can maintain the long-dormant stage of weedy rice seeds. Strong seed dormancy and longer seed viability are among the weedy rice adaptabilities to regulate their emergence and escape unwanted germination in extreme conditions and/or diverse farming practices to ensure their survival in rice agroecosystems (Mispan et al. 2019), especially in the tropical regions. Nevertheless, more analysis needs to be done to further understand the ecological behavior of seed dormancy in weedy rice for tropical regions.

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SUPPLEMENTARY TABLE 1. Phenotypic data for weedy rice collected from IADA, Northwest Selangor

Weedy rice ID	TRAITS					Germination %								
	Pericarp Color	Hull Color	Seed Shattering	Plant Height	Awn	7 d	14 d	21 d	42 d	49 d	56 d	63 d	284 d	284 d at room temperature
Sel-01	Red	Furrowed	Shattered	Tall	Awnless	2.64	5.27	7.91	9.27	11.14	11.14	11.14	97.60	73.33
Sel-02	Red	Furrowed	Shattered	Tall	Awnless	0.00	3.31	8.21	20.13	21.06	25.70	28.74	39.62	6.25
Sel-03	Red	Straw	Shattered	Tall	Awned	0.00	0.79	1.69	2.60	4.29	6.67	7.46	74.42	0.00
Sel-04	Red	Straw	Non-shattered	Tall	Awned	2.86	7.07	10.63	12.38	12.38	12.38	12.38	100.00	63.33
Sel-05	Red	Straw	Shattered	Tall	Awnless	0.00	0.88	0.88	1.86	1.86	1.86	1.86	99.00	73.33
Sel-06	Red	Furrowed	Shattered	Tall	Awnless	11.96	13.41	18.27	20.66	21.38	21.38	22.83	98.98	97.22
Sel-07	Red	Straw	Shattered	Tall	Awnless	10.50	14.72	20.64	23.85	24.86	24.86	24.86	98.53	97.14
Sel-08	Red	Straw	Shattered	Tall	Awnless	1.33	5.23	6.56	15.79	18.46	24.92	27.54	75.00	29.73
Sel-09	White	Straw	Shattered	Tall	Awned	4.15	12.26	19.28	35.62	37.38	40.28	41.43	67.14	0.00
Sel-10	Red	Straw	Shattered	Tall	Awned	0.00	1.11	3.33	25.78	32.89	36.67	42.44	59.38	18.92
Sel-11	Red	Straw	Shattered	Tall	Awnless	10.05	34.45	52.78	64.63	70.87	70.87	80.71	100.00	17.50
Sel-12	Red	Straw	Shattered	Tall	Awnless	7.12	33.66	53.60	63.05	63.05	63.05	63.05	100.00	27.03
Sel-13	White	Straw	Shattered	Tall	Awnless	1.01	1.01	2.02	12.03	22.66	28.77	33.25	78.95	25.00
Sel-14	White	Straw	Shattered	Tall	Awnless	4.36	7.79	12.02	23.24	34.37	38.53	41.85	47.83	3.23
Sel-15	White	Straw	Shattered	Tall	Awnless	24.48	57.69	75.87	86.17	87.56	87.56	87.56	87.56	16.67
Sel-16	Red	Furrowed	Shattered	Tall	Awnless	6.87	31.71	47.69	58.27	59.04	61.61	61.61	100.00	6.25
Sel-17	Red	Furrowed	Shattered	Tall	Awnless	5.66	16.03	23.96	23.48	28.88	33.85	35.65	95.83	8.82
Sel-18	Red	Furrowed	Shattered	Tall	Awnless	2.08	13.60	28.40	47.20	57.46	60.25	60.25	89.47	12.50
Sel-19	White	Straw	Shattered	Tall	Awned	13.57	22.85	30.67	49.95	56.40	57.83	57.83	94.74	5.56
Sel-20	White	Straw	Shattered	Tall	Awnless	18.47	35.61	54.30	72.60	78.54	79.64	80.20	100.00	0.00
Sel-21	Red	Furrowed	Shattered	Tall	Awnless	14.72	18.89	27.43	34.86	39.10	40.14	41.25	97.92	12.50
Sel-22	White	Furrowed	Non-shattered	Tall	Awned	0.00	0.00	0.00	2.43	3.71	4.82	4.82	88.73	6.45
Sel-23	White	Straw	Shattered	Tall	Awned	5.75	8.98	14.64	52.25	52.25	53.23	54.13	97.44	28.13
Sel-24	Red	Straw	Non-shattered	Tall	Awnless	3.70	6.48	8.33	9.26	9.26	9.26	9.26	88.04	41.46
Sel-25	Red	Straw	Shattered	Tall	Awnless	2.12	5.42	7.76	7.76	7.76	7.76	7.76	98.84	92.59
Sel-26	Red	Straw	Shattered	Tall	Awnless	3.98	4.50	4.50	4.50	4.50	4.50	4.50	97.75	90.48
Sel-27	Red	Straw	Non-shattered	Tall	Awnless	0.64	2.95	3.59	5.93	5.93	5.93	5.93	100.00	82.05
Sel-28	White	Straw	Non-shattered	Tall	Awned	2.19	2.19	2.19	2.19	4.41	4.41	4.41	85.23	54.05
Sel-29	White	Straw	Shattered	Tall	Awnless	3.69	6.66	9.56	9.56	9.56	9.56	9.56	96.55	95.12
Sel-30	White	Straw	Non-shattered	Tall	Awnless	17.88	31.16	42.93	55.53	58.90	59.68	60.45	100.00	0.00
Sel-31	White	Straw	Non-shattered	Tall	Awnless	27.49	30.58	36.73	42.92	46.02	47.78	47.78	79.17	2.70
Sel-32	Red	Straw	Shattered	Tall	Awned	13.10	13.10	14.29	14.29	14.29	14.29	14.29	97.22	13.89

Sel-33	White	Straw	Shattered	Tall	Awnless	38.91	53.58	67.66	73.95	75.53	75.53	75.53	87.80	0.00
Sel-34	Red	Furrowed	Non-shattered	Tall	Awnless	3.31	6.34	9.37	9.37	9.37	9.37	9.37	96.15	55.56
Sel-35	White	Straw	Shattered	Tall	Awnless	6.66	14.37	22.48	24.20	25.08	25.08	25.08	98.73	13.51
Sel-36	Red	Straw	Shattered	Tall	Awned	0.00	3.19	5.28	5.28	5.28	5.28	6.51	98.70	67.65
Sel-37	Red	Straw	Shattered	Tall	Awnless	13.90	17.14	22.86	25.14	25.14	26.33	26.33	79.31	86.67
Sel-38	Red	Straw	Non-shattered	Tall	Awnless	4.11	5.80	7.18	8.92	8.92	8.92	8.92	98.23	85.94
Sel-39	Red	Straw	Shattered	Tall	Awnless	0.55	0.55	1.46	1.82	2.18	2.18	2.18	90.10	56.14
Sel-40	White	Straw	Non-shattered	Tall	Awnless	1.25	3.41	5.49	18.21	21.72	22.21	24.20	92.55	10.42
Sel-41	Red	Straw	Shattered	Tall	Awned	3.70	4.94	6.17	7.41	7.41	8.64	8.64	97.22	85.71
Sel-42	Red	Straw	Non-shattered	Tall	Awned	12.10	13.08	15.23	16.31	16.31	16.31	16.31	97.53	95.12
Sel-43	Red	Straw	Shattered	Tall	Awned	2.02	4.11	6.13	7.20	7.20	7.20	7.20	98.98	97.14
Sel-44	Red	Furrowed	Shattered	Tall	Awnless	1.04	1.04	2.08	3.19	4.31	4.31	5.35	93.51	6.25
Sel-45	Red	Furrowed	Shattered	Tall	Awnless	1.88	1.88	2.78	15.18	17.01	18.81	20.69	94.94	42.11
Sel-46	Red	Straw	Shattered	Tall	Awned	3.13	12.17	19.92	25.58	27.50	28.11	28.71	93.62	29.09
Sel-47	Red	Straw	Shattered	Tall	Awnless	0.00	3.54	3.54	3.54	3.54	4.04	4.04	97.42	95.92
Sel-48	Red	Furrowed	Shattered	Tall	Awnless	1.11	3.23	6.57	7.68	7.68	7.68	7.68	97.37	92.68
Sel-49	Red	Straw	Non-shattered	Tall	Awned	9.71	13.66	17.26	17.26	17.26	18.34	18.34	100.00	91.67
Sel-50	Red	Straw	Non-shattered	Tall	Awnless	0.00	0.00	1.01	3.92	3.92	3.92	3.92	93.75	50.00
Sel-51	Red	Furrowed	Shattered	Tall	Awnless	0.00	0.00	0.95	3.81	4.74	4.74	4.74	92.68	72.09
Sel-52	Red	Straw	Shattered	Tall	Awnless	1.63	2.44	4.88	5.69	5.69	5.69	6.88	100.00	94.44
Sel-53	Red	Straw	Shattered	Tall	Awnless	0.00	0.81	1.89	3.78	5.93	7.29	9.44	83.70	17.07
Sel-54	Red	Straw	Shattered	Tall	Awnless	3.35	5.37	6.99	7.81	9.04	9.04	9.04	98.48	35.90
Sel-55	Red	Furrowed	Shattered	Tall	Awnless	0.00	3.92	5.62	11.29	13.54	15.24	15.24	87.63	6.82
Sel-56	Red	Furrowed	Non-shattered	Tall	Awnless	31.73	34.44	43.32	48.20	48.65	49.92	50.37	98.44	38.64
Sel-57	Red	Straw	Non-shattered	Tall	Awned	0.00	0.46	0.93	0.93	0.93	0.93	0.93	77.84	85.42
Sel-58	Red	Straw	Shattered	Tall	Awned	0.00	0.00	0.00	4.62	5.34	5.34	5.34	70.53	8.57
Sel-59	White	Straw	Shattered	Tall	Awnless	0.00	0.56	1.69	2.29	2.29	2.29	2.29	87.72	20.00
Sel-60	White	Straw	Shattered	Tall	Awned	1.15	11.83	17.82	32.24	34.04	34.04	34.70	98.15	89.19
Sel-61	Red	Furrowed	Shattered	Tall	Awnless	0.00	2.28	3.76	9.20	10.72	10.72	16.89	95.56	6.82
Sel-62	Red	Straw	Shattered	Tall	Awned	0.00	6.68	8.74	13.83	15.39	15.89	16.91	100.00	30.91
Sel-63	Red	Furrowed	Shattered	Tall	Awnless	7.72	9.43	14.31	16.84	25.80	30.26	34.64	64.00	3.64
Sel-64	White	Straw	Non-shattered	Tall	Awned	1.57	4.96	9.90	10.69	13.51	15.08	15.85	98.78	90.00
Sel-65	White	Straw	Non-shattered	Tall	Awnless	21.87	28.18	40.29	49.65	51.14	52.55	53.33	62.77	56.25
Sel-66	Red	Straw	Shattered	Tall	Awnless	0.00	1.13	1.13	3.22	4.35	4.86	5.97	98.69	77.42